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EXPERIMENTAL INVESTIGATION FOR REPLACEMENT OF CEMENT BY USING PROPOSIC JULIFLORA FLY ASH WITH ADDITION OF GLASS FIBRES IN CONCRETE

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Abstract - In today's world the main emphasis is on green and sustainable development. Cement industry is one of the major contributors to pollution by releasing carbon dioxide. So, by partially replacing cement with pozzolanic material such as prosopis juliflora ash, the cement industry can serve both the purposes of meeting the demands of construction industry and at the same time providing a green and clean environment. Prosopis juliflora ash is difficult to decompose. So using prosopis juliflora ash is a major step towards sustainable development. Also, the concrete is weak in tension, so with the addition of glass fibres it's compressive and tensile strength is also enhanced. Prosopis juliflora ash is obtained from biomass waste power plants as a waste material. Prosopis juliflora ash does not have cementitious property by itself which is responsible for strength generation. But in presence of water it reacts with free lime obtained from cement and form hydrated products (c2s and c3s) which helps in attaining the strength and also improving the durability. As the prosopis juliflora ash is very fine in structure, it fills more voids and provides superior pore structure and thereby improves its strength at later stages due to reduced permeability.

Key Words: Proposic Juliflora Fly Ash, Compressive, Tensile Strength, Glass Fibre)

1. INTRODUCTION

1.1 GENERAL

In the recent years, growing consciousness about global environment and increasing energy security has led to increasing demand for renewable energy resources and to diversify current methods of energy production. Among these resources, biomass (forestry and agricultural wastes) is a promising source of renewable energy. In the current trends of energy production, power plants which run from biomass have low operational cost and have continuous supply of renewable fuel.

It is considered that these energy resources will be the CO2 neutral energy resource when the consumption rate of the fuel is lower than the growth rate. Also, the usage of wastes generated from the biomass industries (sawdust, woodchips, wood bark, saw mill scraps and hard chips) as fuel offer a way for their safe and efficient disposal. Wood wastes are commonly preferred as fuels over other herbaceous and agricultural wastes as their incineration produces comparably less fly ash and other residual material. A major problem arising from the usage of forest and timber waste product as fuel is related to the ash produced in significant amount after the combustion of such wastes. In this project, cement is replaced by weeds ash to certain percentages of 10%,20%,30%. The different properties of cement, Proposic Juliflora fly ash, fresh as well as harden concrete were studied.

It is commonly observed that the hard wood produces more ash than softwood and the bark and leaves generally produce more ash as compared to the inner part of the trees. The characteristics of the ash depend upon biomass characteristics (herbaceous material, wood or bark), combustion technology (fixed bed or fluidized bed) and the location where ash is collected. As wood ash primarily consists of fine particulate matter which can easily get air borne by winds, it is a potential hazard as it may cause respiratory health problems to the dwellers near the dump site or can cause groundwater contamination by leaching toxic elements in the water.

1.2Proposic Juliflora Fly Ash

Prosopis juliflora ash is the residue powder left after the combustion of wood, such as burning wood in a home fireplace or an industrial power plant. Prosopis Juliflora Ash from the biomass power plant unit in the state of Tamilnadu, India was selected to evaluate its suitability as ash for OPC replacement. The Wood Ash (WA) was obtained from open field burning with average temperature being 700C. The material was dried and carefully homogenized. An adequate wood ash particle size was obtained by mixing wood ash and cement together for a fixed amount of time.

Fig -1: Proposic Juliflora Fly Ash

1.3 BASIC PROPERTIES OF JULIFLORA ASH

The various tests are carried out to determine the chemical constituents of cement. Following are the chemical requirement of ordinary cement as per IS 269-1967/1975: The juliflora fly ash is a black glassy and granular in nature and has a similar particle size range like juliflora ash which indicate that it could be tried as replacement for cement in cementitious. The specific gravity of juliflora ash is varying between 3.15 g/cc. The fly ash is initially mixed with water, the initial pH of extract or leachate may be strongly acidic (pH4) or alkaline (pH12) with time, however, this pH range tends to narrow because of geochemical buffering reactions.

- To reduce the usage of cement in concrete, so that carbon dioxide emission can be reduced.
- To utilize the waste material effectively in concrete.
- To implement the now type of mix design to increase the mechanical properties of concrete.

1.4 SCOPE

It is also expected that the final outcome of the project will have an overall beneficial effect on the utility of weeds fly ash concrete in the field of civil engineering construction work. Following parameters influences behaviour of the weeds fly ash concrete, so these parameters are kept constant for the experimental work. Thus, the scope of the project can be summarized as:

- To obtain mix proportions of cement concrete by IS method.
- To perform the specific gravity test, sieve analysis and slump test under Indian standard methods,
- To conduct compression test on PJFA and control concrete on standard Is specimen size 150x 150x150mm.

1.5OBJECTIVES

- To compare the compressive strength and flexural strength of the Proposic Juliflora Fly ash concrete with the conventional concrete.
- To identify various industrial wastes suitable for utilization in cement manufacture.
- To find economical and environmental helpful solution for high cost of concrete. The physical and chemical properties of Proposic Juliflora fly ash were investigated and compared to ordinary.

2. MATERIAL, METHODOLOGY AND TESTING

2.1 MATERIALS

2.1.1 CEMENT

It is used as an abrasive media to remove rust, Cement is a well-known building material has occupied an indispensable place in construction works. Cement is an extremely ground material having adhesive ingredients. It is obtained by burning together, in a definite proportion, a mixture of ingredients. It is obtained by burning together in a definite proportion, a mixture of naturally occurring argillaceous and calcareous, cooled and ground to the required the required fineness to produce material known as cement.

In general cement is a binder a substance that sets and hardens independently and can bind other materials together. The word `cement` is used to describe masonry resembling modern concrete that was made from crushed rock with burnt lime as binder.

Ordinary Portland Cement was used for casing concrete. This cement is the most widely used one in the construction industry in India. The grade of cement is 53 with specific gravity of 3.15. The initial time and final setting time were found to be 30min and 600min respectively.

2.1.2 AGGREGATE

These are chemically inert, solid bodies held together by the cement. Aggregates come in various shapes, sizes and material ranging from fine particle of sand to large rocks. Because cement is the most expensive ingredients in making concrete, it is desirable to minimize the amount of cement used 70%-80% of the volume of concrete is aggregate keeping the cost of the concrete low. Generally flat and elongated particles are avoided or are limited to about 15% by weight of the total aggregate. Unit weight measures the volume that graded aggregate and the voids between them will occupy in concrete. The void content between particles affects the amount of cement paste required for the mix.

Selecting equal sizes of well graded aggregates reduce the void content. Absorption and surface moisture of aggregate are measured while selecting aggregate because the internal structure of aggregate is made up of solid material and voids that may affect the water cement ratio.

2.1.3 AGGREGATE

2.1.3.1 FINE AGGREGATE

Fine aggregate used for concrete should be properly graded to give minimum void ratio and be free from deleterious material like clay, slit content and chloride contamination etc. Hence grading of fine aggregate is relatively different from that in normal concrete. Grading of fine aggregate should be such that it does not cause increase in water demand for the concrete and should give maximum voids so that the fine cementations particles to fill the voids. Hence it is desirable to use the coarser variety of fine aggregate having a high fineness modulus for making workable and strong concrete. The fine aggregate having are taken in saturated surface dry condition.

2.1.3.2 COARSE AGGREGATE

Local aggregate comprising 20mm, and less than 20mm coarse aggregates in saturated surface dry condition, were used. The coarse aggregates were crushed granite type aggregates. Coarse aggregate was obtained in crushed from majority of the particles were of granite type. The quality is tested using impact test.

2.1.3.3 PROPOSIC JULIFLORA FLY ASH

A juliflora fly ash is the waste product of the material. They are replaced in to cement to give high compressive strength. 90 Microns sieve size Juliflora fly ash are to be used. The specific gravity of wood fly ash to be 2.54 collected from a forestry biomass fired power plant and observed finer particles with average diameter of 50 lm.

Table -1: Physical Properties of Prosopic Juliflora Fly Ash

Physical Properties of Prosopic Juliflora Fly Ash	
Color	Black
Mineralogy	Non crystalline
Particle size	<90 Micron
Specific gravity	2.3

2.1.4 GLASS FIBRE

A material consisting of extremely fine glass fibers, used in marking various products, such as yarns, fabrics, insulators, and structural objects or parts. Also called spun glass. A lightweight, durable material consisting of synthetic resin reinforced with such fibers, used in application such as roofing and boatbuilding.

It is material made lightweight, extremely strong, and robust material. Although strength properties are somewhat lower than carbon fiber and it is less stiff, the material is typically far less brittle, and the raw material are much less expensive. Its bulk strength and weight properties are also very favorable when compared to metals, and it can be easily formed using molding processes. Glass is the oldest and most familiar, performance fiber. Fibers have been manufactured from glass since the 1930s.

2.1.5 WATER

It is the key ingredient mixed with cement, forms a paste that binds the aggregate together. The water causes the hardening of concrete through a process called hydration. Hydration is a chemical reaction in which the major compound in cement form chemical bonds with molecules because the water to cement ratio is the most critical factor in the design of perfect concrete. Excess of water reduces strength and workability of concrete. Portable tap water available in the plant conforming to the requirements of IS456-2000 was used for casting concrete & curing the specimens.

2.2 METHODOLOGY FLOW CHART

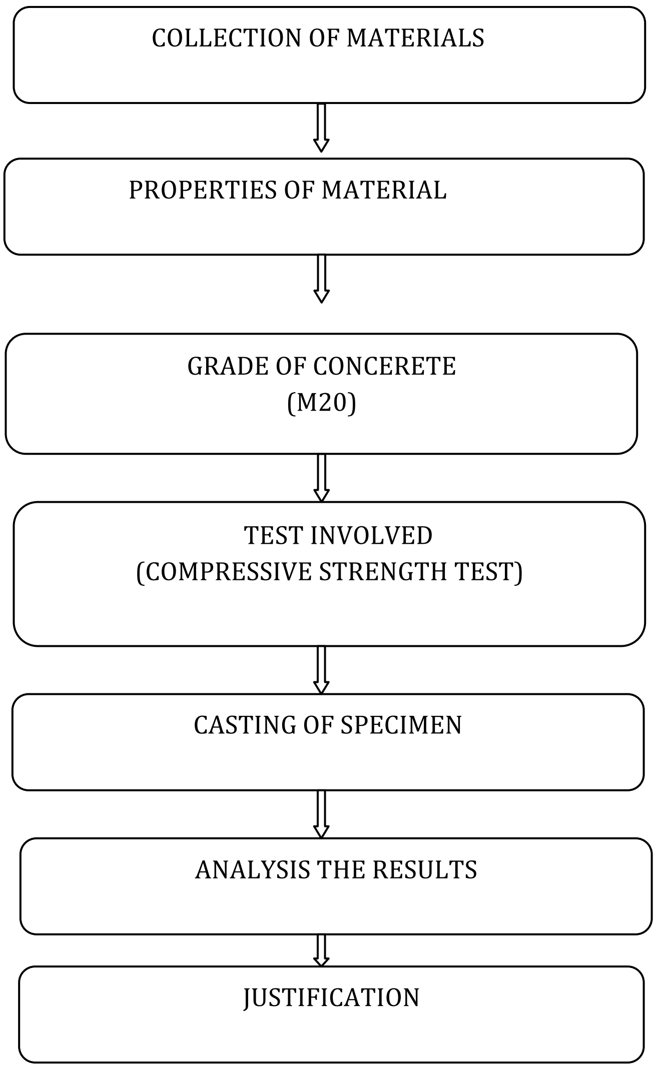

Fig -1: Flow chart

2.3 TESTS

2.3.1 TESTS ON CEMENT

The proportions are given below in volumes. Worth mentioning here is that at all substitutions of cement by juliflora fly ash, the replacement was done by mass, but for practicality purposes, the corresponding weights of the calculated volumes was used while casting the cube, cylinder and beams.

- Fineness Test on Cement
- Consistency Test on Cement
- Specific Gravity

2.3.2 TEST ON JULIFLORA FLY ASH

The Proposic Juliflora ash is tested separately for the following

- Fineness Test on Cement
- Consistency Test on Cement
- Specific Gravity

Fineness Test on Cement

Fineness test on cement is used to determine the fineness of cement by sieving with reference to IS: 8112-1989. Cement is used as a binding material for mortar and concrete. It is found that the particle size of the cement has a paradoxical effect on the strength of concrete. Finer cement offers faster hydration and rapid development of strength. It gives more cohesiveness and reduces bleeding

Consistency Test on Cement

Consistency test on cement is to determine the quantity of water required to reduce a cement paste of standard consistency with reference to IS: 4031 (PART-A)-1988.

Specific Gravity

This test is performed to determined specific gravity of material by using a pycnometer. Specific gravity is the ratio of the mass of unit volume of material at stated temperature to the mass of same volume of gas free distilled water at the stated temperature. IS: 2720 (part 3) 1980, first revision – standard test for specific gravity of material is used as reference for testing.

3. TEST RESULTS

3.1 SPECIFIC GRAVITY TEST

3.1.1 PROPOSIC JULIFLORA FLY ASH

Instrument used = Pycnometer
Material used = Copper slag

Calculations

$$\text{Specific gravity} = \frac{(W2 - W1)}{(W2-W1) - (W3-W4) \times 0.79}$$

Weight of empty flask = 2.75
Weight of flask + PJFA = 3.79
Weight of flask +PJFA +kerosene = 3.79
Weight of flask +PJFA+kerosene = 2.54
Specific gravity of kerosene =0.79
Specific gravity of juliflora ash =3.15 g/cc

FINENESS TEST ON JULIFLORA ASH

Table-2: Fineness Test on Cement

S.NO	Taken weight of cement in kg (w1)	Retained weight of cement kg	Fineness modules of cement (w2)
1	0.1	0.005	0.0073
2	0.1	0.008	
3	0.1	0.009	

Calculation
Fineness modulus of cement =w2/w1

= (0.0073/0.1) X100

= 7.35%

CONSISTENCY TEST ON CEMENT

Table-3: Consistency test of cement

S. No	Weight of cement (gm)	Quantity of water		Index reading		
		In (%)	In (ml)	Initial	Final	Different
1	400	28	112	0	24	24
2	400	30	120	0	15	15
3	400	32	128	0	6	6

FINENESS TEST ON CEMENT

Table-4: Fineness Test on Cement

S.NO	Taken weight of cement in kg (w1)	Retained weight of cement kg	Fineness modules of cement (w2)
1	0.1	0.005	0.0073
2	0.1	0.008	
3	0.1	0.009	

Calculation
Fineness modulus of cement =w2/w1

= (0.0073/0.1) X100

= 7.35%

FINE AGGREGATE

Fineness modules test

Instrument used = Sieve
Material used = sand
Weight of dry fine aggregate = 1000gm

Table- 5: Fineness modules test

Is Sieve	Weight retained in (gm)	%of weight retained	Cumulative %of weight retained	% of passing
6.3mm	-	0	0	100
5.0mm	-	0	0	100
2.36mm	5	0.33	0.23	99.67
1.18mm	130	8.7	6.7	90.67
600 µm	429	28.6	14.56	62.37
425µm	345	23.0	13.34	39.37
300µm	338	22.5	11.34	16.87
212µm	126	8.4	4.56	8.47
150µm	80	5.3	2.35	3.17
63µm	43	2.9	2.31	0.27
PAN	4	0.27	0	0

Calculation:

Fineness modulus of coarse aggregate = cumulative / 100%
= 222.20 / 100
= 2.22%

4. COARSEAGGREGATE

Fineness modules of coarse aggregate

Instrument used = Sieve
Material used = coarse aggregate
Weight of material = 2000 g

Table-6: Fineness modules of coarse aggregate

Is Sieve	Weight of retained (gm)	% of weight retained	Cumulative % of weight retained	% of passing
20	0	-	-	100
13	4	0.3	99.7	99.7
10	18	1.2	98.5	98.5
6.3	119	8	87.3	90.5
4.7	70	4.7	75.90	85.8
2.36	234	15.8	65.93	70.0
PAN	40	2.70	54.89	67.8

Calculation

Fineness modules of coarse aggregate= cumulative /100%

= 510 / 100

=5.10%

3.4 COMPRESSIVE STRENGHT TEST ON CONCRETE CUBE (M20)

FORMULA USED

Compressive strength = (load/area) N/mm^2

3.4.1 Compressive strength for 7 days

Table -9: Compressive strength after 7 days

TRIAL	CONCRETE TRIAL	LOAD IN (KN)	COMPRESSION STRENGTH (N/mm^2)	AVERAGE COMPRESSION STRENGH (N/mm^2)
CC	Conventional Concrete	467 470 467	20.77 20.89 20.74	20.80
CS1	10% Juliflora Ash	470 480 488	20.88 21.04 21.54	20.92
CS2	20% Juliflora Ash	484 496 513	21.00 22.40 22.54	22.30
CS3	30% Juliflora Ash	505 482 495	22.80 21.00 21.80	21.90

Therefore, CS3 have a better strength when compared with others after 7 days

3.4.2 Compressive strength for 28 days

Table -10: Compressive strength after 28 days

TRIAL	CONCRETE TRIAL	LOAD IN (KN)	COMPRESSION STRENGTH (N / mm^2)	AVERAGE COMPRESSION STRENGTH (N / mm^2)
CC	Conventional Concrete	649 642 646	28.84 28.54 28.73	28.70

CS1	10% Juliflora Ash	755 760 763	33.54 33.78 33.89	33.73
CS2	20% Juliflora Ash	848 854 860	37.87 37.90 38.87	38.21
CS3	30% Juilflora Ash	833 815 823	37.89 36.90 36.14	36.54

Therefore, CS3 have a better strength when compared with others after 28 days

3.4.3 RESULTS FOR COMPRESSION TEST

Table -11: Compression test results After 7 & 28 days

TRIAL	Mix	7 Days	28Days
CC	Conventional Concrete	20.80	28.70
CS1	Juliflora Ash10%	20.92	33.73
CS2	Juliflora Ash 20%	22.30	38.21
CS3	Juliflora Ash30%	21.90	36.54

3.4.4 COMPRESSION STRENGTH AFTER 7 DAYS 7& 28DAYS

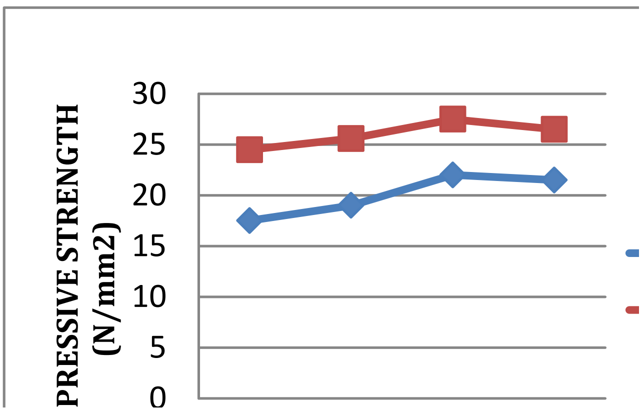

Chart-1: Compression strength results

3.5 Cost Analysis

Cost analysis is the very important factor to be considered, while analysing the project. The cost analysis for various mixes per m3 is shown in Table no 12.

According to that, the cost for reference concrete mix specimen took Rs 5817.4. per m3. Replacing 10%, 20%, 30%, 0f Proposic Juliflora fly Ash, it cost should be low when compared with "R".

Table -12: Cost of Material

Material	Quantity	Rate
Cement	1bag(50Kg)	420
Juliflora Ash	1bag(50Kg)	150
Fine aggregate	Per Cft	5200
Coarse aggregate	Per Cft	3500

where,
1 unit = 100 cft
1 unit = 2830 kg

Table -13: Rate of material per "kg"

Material	Rate
Cement	4.5
Juliflora Ash	3.5
Fine aggregate	2.6
Coarse aggregate	2.4

Table -14: Total Cost of Materials for M20 design mix concrete (1:1.53:3.45) per m3

S. no	MIX	Consumption of Design Proportion For M20 concrete (1:1.53:3.45)				TOTAL COST per "m3"	% COST SAVING
		C	F. A	PJFA	C.A		
1	CC	372	570	-	1286	5817.4	-
2	CS 1	372	513	57	1286	5902.9	1.46
3	CS 2	372	456	114	1286	5988.4	2.93
4	CS 3	372	399	171	1286	6073.9	4.40
5	CS 4	372	342	228	1286	6159.4	5.78
6	CS 5	372	285	285	1286	6244.9	7.34

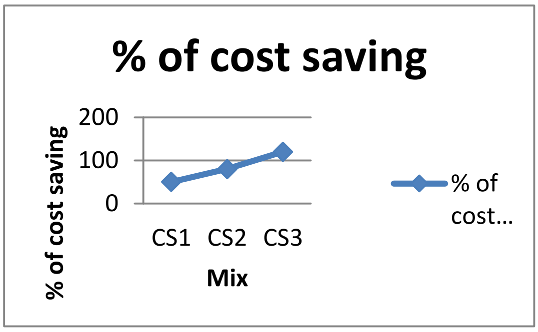

Chart-2: Percentage of improvement of cost Analysis

4. WORKABILITY TESTS

Slump Cone Test

From the workability test results, slump value slightly decreases for concrete mixes with Copper slag when compared with reference concrete mix (R).

Slump cone test

Concrete mix ratio = 1:1.68:2.76, M20grade

Weight of cement = 2500gm

Weight of fine aggregate = 3750gm

Weight of coarse aggregate = 4500gm

Fig-2: Slump cone

Table -15: Slump cone test

Water ratio	Water added in (ml)	Initial height		Final height h_1-h_2	Slump in (mm)
		h_1	h_2		
0.58	1250	300	250	50	50
0.55	1375	300	120	120	120
0.60	1500	300	155	145	145

The slump value of concrete is,

- 50mm for 0.5 w/c
- 120mm for 0.55 w/c
- 145mm for 0.60 w/c

After 7 days curing

From the experimental test results, the compressive strength of concrete mix of cube having 30% of copper slag (CS3) has the higher strength of 22.90Mpa.

After 28 days curing

From the experimental test results, the compressive strength of concrete mix of cube having 40% of copper slag (CS4) has the higher strength of 40Mpa. By analysing its cost and strength parameters concrete mix having 40% replacement of Sand by Copper slag (CS4) is comparatively more economical. From workability, strength test and cost analysis, it is found those concrete mix with 40% replacement of Sand by Copper slag give better result and hence used to construction purpose.

5. CONCLUSION

Based on the test results obtained from the experimental program of this work the following major calculations are arrived from workability, compressive strength and cost analysis.

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